Oh Where Have All the Monarchs Gone?

budburst
A project of the Chicago Botanic Garden

Ecosystems Unit Overview: Plants, Pollinators, & People

Fifth Grade: Matter and Energy in Organisms and Ecosystems

Middle School: Interdependent Relationships in Ecosystems

Nativars Research Question: Should we include cultivars in our native pollinator garden?

Time needed

Core Activities: five lessons requiring 7-10 45-minute periods

Supplemental Activities: five lessons requiring 5-8 45-minute periods. Supplemental activities provide additional supporting NGSS aligned content, but are not required to complete the unit.

Lesson Overview

	Lesson	# of Classes	Title	Description
Core	1	2-3	Firefighters to the Rescue!	Introduces the storyline, the Nativar garden, and pollinator observations
Core	2	1-2	A Milkweed Habitat	Interspecies relationships
	3	1-2	Habitats, Chains & Webs	Food chains and food webs
Core	4	1-2	Patient Pollinator Count 1	Collecting pollinator data in the field
	5	1-2	UV Bee: Pollinator Super Powers	Pollinator vision and flower structure, and example of interspecies relationships
	6	2-3	Is this my Habitat?	Biotic and abiotic components of an ecosystem
	7	1	Patient Pollinator Count 2	Second round of data collection
Core	8	1-2	Plotting Plants and Pollinators	Data analysis
	9	1-2	Pea Patch Pollinator Game	Impacts of pollination on plant populations
Core	10	2-3	Coming Back Home: A Success Story	Drawing conclusions from the data, proposing solutions based on their results

Contents

1. Storyline

Scientist Role For Your Students

For the next few weeks each of your students will take on the role of a scientist. As participants in a community science project - Budburst Nativars Research Project – your students will be collecting *real* data and contributing to important research. This provides a framework for them to see themselves as authentic scientists! As the teacher, you have the unique opportunity to model the processes, resources, skills, procedures, and patience required to do science. Consider yourself an onsite head researcher mentoring this year's crop of new scientists.

Scientists look at phenomena and ask questions about what they observe. They develop questions that can be answered by researching and collecting evidence. So let's start with a phenomenon your students have most likely heard about. Declining numbers of pollinators.

NOTE: This curriculum was developed using an NGSS storyline/anchor phenomenon aligned to the NGSS (Next Generation Science Standards) standards for fifth grade and middle school. There are resources listed in the Reference List for educators wishing more information about this method for designing a curriculum.

Anchor Phenomenon/Storyline

(Photos courtesy of Pascal Sabino)

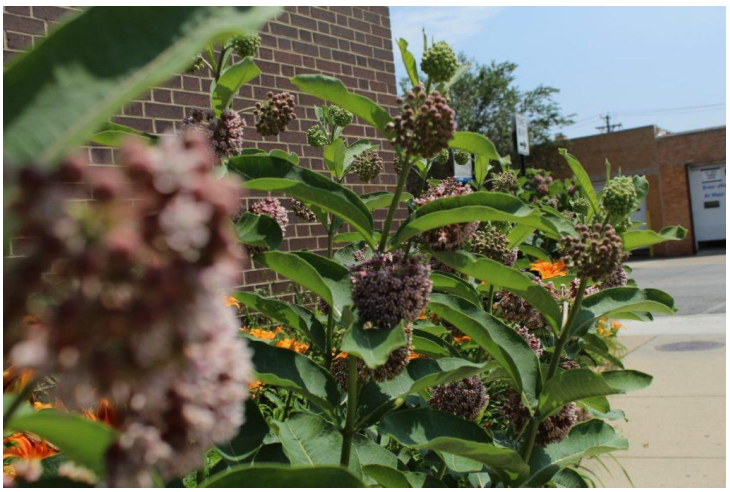
A locally generated storyline about the plight of monarch butterflies and habitat loss of interdependent plant species is being used for the Chicago area schools in Illinois. The article is below, and you can read the actual article at the URL provided. There are many similar stories that can be found online for different areas of the country. If you are not in Illinois, consider choosing a local story about how a group or community has banded together to make a difference as 'community scientists.'
This storyline comes from an article out of the BlockClubChi.org newsroom online. Block Club Chicago is a not-for-profit organization purporting to support sustainable journalism. A local journalist, Pascal Sabino, wrote this article about a firehouse in Chicago's Austin neighborhood. See article, "How West Side Firefighters Turned Their Firehouse Into A Safe Haven for Monarch Butterflies and Native Plants" (July 8, 2019). Or at: https://blockclubchicago.org/2019/07/08/monarch-butterflies-flock-to-austins-engine-68-firehouse-after-it-embraces-milkweed-and-native-plants-outside/

NOTE: For more mature readers or for a larger community focus, this article about the city of Austin, Texas' efforts to be a critical mitigation point for the monarch butterfly provides a similar storyline of a larger metropolitan area and how it can positively impact a comeback on a threatened or endangered species. The article about Texas' Austin is titled, "Austin, Texas Creates Habitat for the Declining Monarch Butterfly," August 3, 2015 by Patrick Fitzgerald. See article at: https://blog.nwf.org/2015/08/austin-texas-creates-habitat-for-the-declining-monarch-butterfly/

The story (as reported by Pascal Sabino):

Just beside the corner of Grand and Lockwood avenues sits a lush, green area dense with wildlife native to the Illinois prairie.

A monarch butterfly circles overhead while hundreds of honeybees poke in and out of the pink-and-purple blossoms in search of nectar. Spotted beetles feed on the foliage while caterpillars and other larvae hang from the undersides of the rubbery milkweed leaves.



Milkweed plants growing at the Chicago area fire station (Photos courtesy of Pascal Sabino)

This thicket of shrubbery, flowers and prairie grass sits in the center of a largely industrial area in north Austin on the city's West Side. It isn't one of the city's nature parks – this is the Chicago Fire Department's Engine 68 firehouse.

"We always had flowers and everything out there," said Steve Somogyi, an engineer at the firehouse who decided to let native plants take over the station's garden. "And just out of the course of nature being nature, one or two milkweeds popped up, and we knew what they were and we left them alone."

By deciding not to pull out the milkweeds, Somogyi allowed the garden to become a habitat for all kinds of insects. Most notably, the leaves of the milkweed are the only food source for the monarch caterpillar. "Over the course of two years, three years, you know, they're weeds – they grow like weeds. And then we see the caterpillars and you see the butterflies," Somogyi said.

Monarch butterfly populations have seen a sharp decline in recent years due to a decrease in the milkweed plants they rely on for reproduction in northern migratory zones. But monarchs aren't the only species struggling with habitat loss.

According to the Illinois Department of Natural Resources, the grasslands that once spanned across the Midwest have seen a steep decline. Of the 22 million acres of natural prairie that once covered 60 percent of the state, now only 2,500 acres remain. And as the prairie habitats have shrunk in the Chicago area and beyond, the familiar wildlife native to those ecosystems have become scarcer.

"It's not like when we were kids anymore. I mean look, you used to go out when you were a kid on a hot summer night, and you'd see millions and millions of lightning bugs. Or you'd see grasshoppers all over the grass, and monarch butterflies," Somogyi said. "Now you don't see any of the three."

Somogyi is glad the lot can be used not only to beautify the neighborhood, but also to help preserve the natural wildlife that once was ubiquitous in the region. He plans on spreading milkweed seeds behind the firehouse as well, and says that supporting native plant species is a much better use of space than maintaining the type of green manicured lawn that would never be found in nature.

"There used to be, I think, two patches of grass out here you know," he said. "What purpose does that serve?"

While Somogyi has largely taken the lead on propagating the milkweed plants at the firehouse, he says that others have followed suit and started to grow milkweed in their own gardens with hopes of welcoming the monarch butterflies to their homes.

An added benefit to growing a native plant like milkweed is that they are incredibly hardy and well-adapted to the climate and soil conditions. Unlike the delicate lawn grasses native to Europe, prairie species have evolved to thrive in the Midwest even without routine care.

“The flowers need the water and stuff. But like the milkweed could probably take a blowtorch to it when they would come back,” said Somogyi.

“Even beyond the firehouse and people’s homes, the city’s urban ecosystem would benefit from restoring open spaces with native grasses [and other native plants],” Somogyi said.

In the open lots and vacant spaces that have become abundant in parts of the west side, he sees an opportunity to help the city coexist with nature. “Native plants and animals to the Midwest might as well be allowed to flourish in the otherwise unused lots,” he said.

He ended with, “There’s this whole swath of grass. Why couldn’t it be prairie?”

2. Unit Overview: Curriculum structure and standards alignment

Curriculum Structure: The curriculum is made up of ten total activities that take approximately 2-3 weeks to complete, 45 minutes/day. Activities are divided into five core activities and five supplemental activities that provide additional NGSS aligned supporting content. Core activities can be completed as a stand alone unit and will take five-six 45 minute periods to complete.

Grade(s) 5-8	**Time Recommendations: 12-15 class periods**
Central Focus: Students will be community scientists in this unit and learn how real scientists make observations (collect data) in order to answer a research question. They will practice making observations. As they learn about the relationships between the milkweed and its pollinators, they will understand how important native plants are to those insects that rely on them for food and shelter. Then students will describe why they rely on plants and pollinators for survival. Students will revisit the Nativars Research question and consider other possible investigations.	**Student Objectives** – students will know and be able to: 1. Make observations of pollinators pollinating flowers, and they will collect data in order to make a claim and support it with evidence. 2. Explain how changing an environment will affect a place's availability of resources to support native plants and pollinators. 3. Create connections between plants, pollinators, and people in order to support plants and pollinators and coexist with them. 4. Describe the importance of plants and pollinators to the survival of humans.
Essential Question(s): How does a ***change**** in an ecosystem/habitat impact pollinators' abilities to find shelter, food, and a place to lay their eggs? How might we support their needs to ensure places for them to live and thrive? What kinds of research might we do and what kinds of research questions should we ask in order to support plants and pollinators?	*Note: *Changes in an ecosystem might include human impacts of farming, building roads and subdivisions, etc., or natural phenomena such as extreme weather conditions or loss of interdependent species.*

Lesson Overview

	Lesson	# of Classes	Title	Description
Core	1	2-3	Firefighters to the Rescue!	Introduces the storyline, the Nativar garden, and pollinator observations
Core	2	1-2	A Milkweed Habitat	Interspecies relationships
	3	1-2	Habitats, Chains & Webs	Food chains and food webs
Core	4	1-2	Patient Pollinator Count 1	Collecting pollinator data in the field
	5	1-2	UV Bee: Pollinator Super Powers	Pollinator vision and flower structure, and example of interspecies relationships
	6	1	Is this my Habitat?	Biotic and abiotic components of an ecosystem
	7	1	Patient Pollinator Count 2	Second round of data collection
Core	8	1-2	Plotting Plants and Pollinators	Data analysis
	9	1-2	Pea Patch Pollinator Game	Impacts of pollination on plant populations
Core	10	2-3	Coming Back Home: A Success Story	Drawing conclusions from the data, proposing solutions based on their results

Alignment with The Next Generation Science Standards (NGSS)

All of the lesson plan activities have been aligned with the NGSS standards. There are different standards depending on which of the three investigations are being taught. Each lesson plan has the following information in the lesson plan format below:

Performance Expectations

Fifth Grade: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment. (5-LS2-1)

Middle School: Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (MS-LS2-2)

Clarification Statement

Fifth Grade: Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.

Middle School: Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions could include competitive, predatory, and mutually beneficial.

Assessment Boundary

Fifth Grade: Assessment does NOT include molecular explanations.

Middle School: None

Common Core Connections: Where they are relevant, each activity/lesson plan has an ELA/Literacy and/or Mathematics connection identified.

FIFTH GRADE	FIFTH GRADE	FIFTH GRADE
Science and Engineering Practices: 5-LS2-1	**Disciplinary Core Ideas: LS2.A**	**Crosscutting Concepts: 5-LS2-1)**
Fifth Grade: Developing and Using Models Develop a model to describe phenomena. (5-LS2-1) **Connections to Nature of Science:** Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena Science explanations describe the mechanisms for natural events. (5-LS2-1)	**Fifth Grade: Fifth Grade: Interdependent Relationships in Ecosystems** The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms such as fungi and bacteria, break down dead organisms (both plants or plants' parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly	**Fifth Grade: Systems and system Models** A system can be described in terms of its components and their interactions. (5-LS-1) **Energy and Matter** Matter is transported into, out of, and within systems. (5-LS1-1)

	introduced species can damage the balance of an ecosystem. (5-LS2-1)	
MIDDLE SCHOOL	**MIDDLE SCHOOL**	**MIDDLE SCHOOL**
Science and Engineering Practices: MS-LS2-2	**Disciplinary Core Ideas: LS2.A**	**Crosscutting Concepts: MS-LS2-2**
Middle School: Constructing Explanations and Designing Solutions Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)	**Middle School: Interdependent Relationships in Ecosystems** Similarly, predatory interactions may reduce the number of organisms or eliminate whole populations of organisms. Mutually beneficial interactions, in contrast, may become so interdependent that each organism requires the other for survival. Although the species involved in these competitive, predatory, and mutually beneficial interactions vary across ecosystems, the patterns of interactions of organisms with their environments, both living and nonliving, are shared. (MS-LS2-2)	**Middle School: Patterns (MS-LS2-2)** Patterns can be used to identify cause-and effect relationships. (MS-LS2-2)

Lesson Format

Each lesson is written up in the 5 E science lesson format below (*Engage, Explore, Explain, Extend, and Evaluate*). For schools unfamiliar with the 5 E Inquiry Science Lesson Model, please see the Reference List for resources. (Also, other verbiage has been added below to provide context to other lesson plan models.)

- **Engage** (Inquiry/Anticipatory Hook/Opening/Activate Prior Knowledge/Create Interest/Orient to Content)
- **Explore** (Conceptualizing Concepts/Student Activities/Instructional Strategies and Learning Tasks/Development of the Concept)
- **Explain** (Checking for Understanding/What the students are doing to construct meaning and what the teacher is doing to facilitate the process)
- **Extend** (Applying New Knowledge/Guided Practice/Independent Practice)
- **Evaluate** (Closing/Exit Slip/Wrap Up/Tie Up the Lesson/Provide Cognitive Closure)

Each lesson will have the following components

1. **Central Focus, Time Recommendations, Student Objectives, and Essential Question in the format below**

Grade(s) 5-8	**Time Recommendations: Number of class periods**
Central Focus: Describes the main activities of the lesson.	**Student Objectives** – students will know and be able to…Describes student outcomes
Essential Question(s): Describes the driving questions for the lesson	**Notes:** any additional implementation information

2. **Vocabulary list**
   Every lesson will have a set of vocabulary words that will be used during that lesson's activities. Students could create vocabulary cards using index cards. Some of the terms are repeated in several lessons. The aim is not for students to memorize definitions and spellings, but for students to know when and how to use them in their writing and hands-on activities. Having students make vocabulary cards and practicing reviewing them on a daily basis (or playing games like Kagan's "Quiz, Quiz, Trade", will help reinforce their understanding of the concepts being learned in this Life Science Unit.

3. **Materials List**
   Each lesson will have its own list of materials needed in order to conduct the activities. Some materials should be on hand for all of the activities. These include a student spiral that can be used as their science journal, writing utensils, rulers, scissors, hand lenses, construction paper and typing paper.

4. **Advance Preparation and Teaching Tips**
   Every lesson will have this section completed for that specific lesson.

5. **Pre-teaching/Background Knowledge/Misconceptions**
   Sometimes this section will have information about student misconceptions and sometimes there will be ideas for how to pre-teach the lesson.

6. **Formal and/or informal assessment suggestions**
   Informal Assessments: These formative assessments can be conducted by the teacher throughout the lessons to check for student understanding and to inform lesson plans moving forward (Assessment FOR Learning). They might include using graphic organizers for individual lesson components, checking for understanding with strategically-placed, probing questions, and they might include ways to weed out student misunderstandings or to see what students already know and understand by using KWLs or Probes (see resource on Page Keeley) or pre-tests.

   Formal Assessments: These are summative assessments conducted by the teacher that assess what the student has learned (Assessment OF Learning). These would usually be administered at the end of a unit. See below for suggestions.

Potential Unit Assessments

- Budburst Nativars Poster Symposium – As students move through the lessons, they may build their own research question around the Nativars data they are gathering. At the end of the formal lessons, they might present their findings in a Budburst Nativars poster session set up where they visualize their data, and state their conclusions. This could be an organized community event publicized as a Community Scientist Symposium or more informally, students could share their posters with classmates from another second or fourth grade class.
- Science Notebook – Students maintain a notebook that includes personal reflections on their learning, drawings of pollinators and flowers highlighting pollinating structures, etc. This journal could also be helpful in organizing their information if they create posters at the end of the unit. A simple spiral notebook should be used just for science.
- Students will be taking a pre- and post-survey. The content questions on the survey may be used by the teachers as a formal assessment at the end of the unit.

7. Additional Resources

Teacher and student resources including background information, links, and references.
Every lesson will have this section completed for that specific lesson.

3. Lesson Summaries

Unit: Oh Where have All the Monarchs Gone?

A Phenomenon in Real Life:

What can be done to help the monarch butterflies and other pollinators make a comeback?

Connection to Budburst Nativars:

One of the problems affecting the monarch butterfly (and other insect pollinators) decline is destruction of their habitat. So researchers suggest we grow native plants to help the all of the pollinators. Many local plant nurseries do not differentiate between native plants and their cultivated species, nativars. That's why the Chicago Botanic Garden plant scientists have launched the Budburst Nativars Research Project – to determine if it matters whether native plants or nativars are planted in our gardens.

That's why we need your help. The Budburst Nativars Research Project needs you and your students to be scientists and help answer this question:

Do pollinators prefer cultivars of native plants species (nativars) or true native plants?

Lesson 1: Firefighters to the Rescue! (CORE)

Students will be introduced to the local firehouse in a Chicago neighborhood that will begin their thinking about how a small group of people can make a difference for plants and their pollinators. Then students will have an opportunity to put on their community scientist hats and learn about data collection guidelines (that will scaffold into protocols in lesson 4), as they make their first, informal observations in their Nativars Research Gardens, local school garden, or through observing pollinators on a video clip.

Lesson 2: A Milkweed Habitat (Core)

In this lesson, students are formally introduced to the term "interspecies relationships" as they learn how a milkweed plant can be a community of organisms that depend upon each other to survive. They will learn about several types of relationships including mutualistic and predator-prey interactions.

Lesson 3: Habitats, Chains and Webs

Using some of the organisms in Lesson 2 (Milkweed Habitat) and organisms in other ecosystems, students will create simple food chains and food webs to make connections between the flow of energy and matter through a system (ecosystem). They will be introduced to how an ecosystem encompasses both living (biotic factors) and nonliving (abiotic factors) components of an area; whereas a habitat refers to the physical place in which an organism lives.

Lesson 4: Patient Pollinator Count 1 (Core)

In your school yard or Nativars Research Garden, students will watch a plant for 10 minutes to observe pollinator visits. They will follow a sequence of steps (a protocol) in order to make scientific observations to determine how many, and what types of pollinators visited their plants. They will be able to respond to questions like, "In what habitat is your Nativar Research Garden located?" Or "How

have these plants and animals (animals as pollinators) adapted to your habitat?" (If the weather is inclement OR there are no flowering plants available, use the video clips available on p. 13 under Unit Resources to take the place of actual outdoor observations.)

Repeat this activity at least once a week while the plants are flowering. Later, you will use the "Plotting Plants & Pollinators" lesson activity to help students organize, visualize, and present the collected data. Students will participate in real scientific research.

Lesson 5: UV Bee: Pollinator Super Powers

In the fourth grade curriculum, a lot of time was spent developing the idea that flowers have special ways to attract pollinators. Pollinators also have special abilities to see what flowers they are more attracted to; however, bees can't distinguish red and butterflies are legally blind! This lesson hones in on one super power that many insects have – especially the bees and butterflies. They see using not only some of the visible light spectrum, but also the ultra-violet light spectrum. We protect our eyes and skin from UV light waves, yet the insects have the ability to use these light waves to 'see' flowers differently than you or I do. Students should use this information when they decide which flowers to put in any gardens they want to create that will attract specific pollinators.

Lesson 6: Is This My Habitat?

This activity introduces students to the major components that make up an ecosystem; how biotic and abiotic factors determine what organisms can survive and thrive in that ecosystem; and how living things are interconnected and depend on each other for survival.

Lesson 7: Patient Pollinator Count 2

This is at least the second time to get outside and observe pollinators while the plants are flowering. (In another lesson, you will use the "Plotting Plants & Pollinators" lesson activity to help students organize, visualize, and present the collected data.) Students will participate in real scientific research. In your school yard or Nativars Research Garden, watch a plant for 10 minutes. How many, and what types of pollinators come to your plant? Is that different from what other students/teams saw? Report and suggest why you saw differences.

For Nativars Research Gardens: Report your findings to budburst.org. In what habitat is your Nativar Research Garden located? How have these plants and animals (animals as pollinators) adapted to your habitat? (If there are no flowering plants available, use the video clips that have been made available under Unit Resources on p. 13 of this document to take the place of actual outdoor observations.)

Lesson 8: Plotting Plants & Pollinators (Core)

This is a class analysis of data to help students answer the question: **Do pollinators prefer cultivars of native plant species (nativars) or true native plants?** Through this process, students will practice identifying visual comparisons to explore within a dataset, summarizing data, transforming data from tables to graphs, recognizing and describing trends in data, and posting new research questions based on their results.

Lesson 9: Pea Patch Pollinator Game

Students play a simulation game modeling changes in a plant population (a Pea Patch) caused by patterns of pollination. The game shows that variation in flower color can lead to greater pollination and therefore greater seed production of one flower type, changing the population of pea plants over time. Discuss potential implications for changes that might affect pollinator preference. Determine how this information can be combined with the information learned in the lesson on how insects see to help research scientists better understand if nativars should be included in pollination gardens.

Lesson 10: Coming Back Home: A Success Story! (Core)

Students have been learning about how pollinators have preferences and how flowers attract specific pollinators by providing characteristics that pollinators look for. Perhaps the pollinators use their super powers of sight or perhaps the flower's shape makes it easier for the pollinator to come into contact with that flower to find and drink the nectar. In this final lesson, students will determine how they might be the solution to the problem of decreasing habitats for our pollinators. They should review some of the ideas they came up with for new research projects during the data analyses they completed in lesson 9. They should work in small groups or individually to come up with a new research project. As they prepare poster presentations, their research question may be predominantly placed on their poster and their research could be highlighted by creating a garden plot drawing with plants that will attract the most pollinators or by drawing an ecosystem that shows several interspecies relationships in that ecosystem. These drawings may be the basis for ideas for new research questions.

4. Unit Resources:

The following are extra resources that may be useful to you during completion of this unit:

1) **Pollinator Videos from Chicago Botanic Garden:**
   Students can use videos (linked below) to practice their pollinator identification skills and the Budburst Nativars data collection protocol. These videos can be used in lieu of outside observations on your Nativars gardens during bad weather, etc.
   - https://youtu.be/VfQaVDr9TGE (3 minute video)
   - https://youtu.be/xdJFXZFLOb8 (10 minute video)

2) **Plant Guide with Images** (also downloadable under Unit Resources on the curriculum page)
   This page includes images of the native species and their cultivars (nativars) planted in Nativar gardens in the Midwest. (e.g. aromatic asters, black-eyed susans, etc.)

3) **Pollinator ID Activity**
   Test your ability to identify different types of pollinators with the Pollinator ID game! Review the ID guide and the characteristics of each, and then see if you can identify each of the pollinators in the photos provided. This activity can help prepare students for their observations in Lesson 3.

4) **Pollinators and Nativars: What's the Buzz (Powerpoint)**
   This Powerpoint explains why pollinators are important, how nativars are created, what characteristics appeal to different pollinators, and how to identify different pollinator types . Use as background information, or present as a lesson for your students.

Reference List:

Resources for using storylines and the NGSS standards:

Next Generation Science Storylines at: http://www.nextgenstorylines.org/

Questions to Guide the Development of a Classroom Culture That Supports "Figuring Out" at: https://static1.squarespace.com/static/56ef1da37da24f301fccaacd/t/594e94c659cc68f8dfc57ede/1498322119719/Five+Questions+To+Guide+3DL+Units.pdf

Other Resources:

Illinois Agriculture in the Classroom. Prairies and symbols. Accessed on August 1, 2019 at: http://www.agintheclassroom.org/TeacherResources/Lesson%20Booklets/Prairie%20and%20Symbols.pdf

Photos of Austin firehouse: Courtesy of Pascal Sabino/Block Club Chicago

Budburst Nativars Contacts:

Sarah Jones, Ph.D., Budburst Education Manager, sjones@chicagobotanic.org

Budburst, info@budburst.org